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ABSTRACT

A major effort of Project Synthesis was the analysis of written reports, problem statements, new foundation programs, and current research that provided clues as to ideal state conditions in science teaching. A classification scheme that included five focal areas was used in the Project (elementary science, biology, physical science, inquiry, and science/technology/society). The 1981 Iowa Curriculum Update Conference focused upon Project Synthesis results. Each day began with an analysis of the ideal/desired state condition in each of the five focal areas. Following such a presentation/analysis, small groups examined sample curriculum materials and/or discussed the meaning further. In the afternoon a session was devoted to the actual state condition (as evidenced by National Science Foundation status studies and the National Assessment of Educational Progress Third Assessment of Science). Such information was used in discussion of the discrepancies between ideal state and actual state conditions. Each discussion was aimed at the conference theme: moving toward the desired state in science teaching. In addition to the conference program, summaries of all sessions are provided (noting that where omissions occur, the conference leader for the particular session chose not to provide the summary information). (JN)

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Proceedings of Annual Curriculum Update Conference

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TOWARD THE DESIRED STATE
IN SCIENCE TEACHING

June 21-26, 1981

SE 041 457

Science Education Center. The University of Iowa, Iowa City, Iowa 52242

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Foreword

The first general report of the Project Synthesis effort was released in April of 1981 at the national convention of the National Science Teachers Association. A major part of this effort was the analysis of written reports, problem statements, new foundation programs, and current research that provided clues as to ideal state conditions in science teaching. For Project Synthesis a classification scheme that included five focal areas was used; these areas were elementary science, biology, physical science, inquiry, and science/technology/society.

The 1981 Iowa Curriculum Update Conference focused upon the Synthesis results. Each day began with an analysis of the ideal or desired state condition in each of the five focal areas. Following such a presentation/analysis, small groups examined sample curriculum materials and/or discussed the meaning further. In the afternoon a session was devoted to the actual state condition (as evidenced by the NSF Status Studies and the NAEP Third Assessment of Science). Such information was used in discussion of the discrepancies between ideal state and actual state conditions. Each discussion was aimed at the conference theme, namely moving Toward the Desired State in Science Teaching.

The Project Synthesis effort is significant in its identification of directions for which there is evidence and rationale of its desirability. Such ideals are not meant to be prescriptive nor single directions. They are meant to be the best judgments - based on extensive evidence - concerning desirable features of elementary science, biology, physical science, inquiry, and science/technology/science. Such considerations provide a base for exciting discussions regarding alternate directions as well as procedures/conditions needed for moving toward such teaching.

The conference format and the record of the various program features provides a record of the success of the conference. Summaries of all sessions follow. Where omissions occur, the conference leader for the particular session chose not to provide the summary information. Hopefully this will not detract from the general record nor influence the directions that were identified during the course of the conference.

We are indebted to all members of the conference staff who shared experiences and ideas so generously. We are also indebted to the participants who added an essential ingredient to the analyses and the daily discussions.

Robert E. Yager

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PROGRAM

Sunday, June 21, 1981

TIME	SESSION	LOCATION
12:00	Check into dormitories	Burge Hall
5:30 p.m.	Reception, Cold Snacks, Registration	474 PB
7:30	Welcome - Essie Beck, NSSA Introduction of Staff - Robert Yager	474 PB
8:00	Tour of Science Education Center	Physics Building

Monday, June 22, 1981

8:30 a.m.	Desired State of Elementary Science, David Butts, University of Georgia	301 PB Commons Room
9:30	Coffee	316 PB
9:45	Break-out--Discussions	
	A. Discussion of 8:30 Session, Orrin Gould, Discussant	474 PB
	B. Discussion of 8:30 Session, Ken Hartman, Discussant	456 PB
	C. Human Science Program as Exemplary Model, Robert E. Yager, Discussant	362 PB
11:00	Special Session 1-"Are We Really Assessing Student Intellectual Development?", Darrell Phillips, University of Iowa	474 PB
12:00	Lunch	
1:30 p.m.	Actual State of Elementary Science and Recommendations for Future, David Butts, University of Georgia	301 PB Commons Room
2:30	Break-out--Discussions	
	A. Discussion of 1:30 Session, Orrin Gould, Discussant	474 PB
	B. Discussion of 1:30 Session, Ken Hartman, Discussant	469 PB
	C. Health Education as a Part of Science, Dan Sheldon, Discussant	362 PB
3:30	Coffee	474 PB 469 PB 362 PB

PROGRAM

Monday, June 22, 1981 (cont'd)

3:30 p.m.	Special Session 2 - "Accomplishments & Needs in Science Education," Robert E. Yager	474 PB
5:00	Open Discussion and Review of Materials	474 PB
6:00	An Evening With Dan Sheldon	1300 Ashley Drive
7:15	Snacks, Conversation, Conviviality	

Tuesday, June 23, 1981

8:30 a.m.	Desired State of Physical Sciences, Ronald Anderson, University of Colorado	301 PB Commons Room
9:30	Coffee	316 PB
9:45	Break-out--Discussions	
	A. Discussion of 8:30 Session, Orrin Gould, Discussant	474 PB
	B. Discussion of 8:30 Session, Ken Hartman, Discussant	456 PB
	C. The ISIS Program, Jan Wielert, Discussant	362 PB
11:00	Special Session 1 - Safety & School Science, Gary Downs, Iowa State University, and Jack Gerlovich, Department of Public Instruction	474 PB
12:00	Lunch	
1:30 p.m.	Actual State of Physical Sciences and Recommendations for Future, Ronald Anderson, University of Colorado	301 PB Commons Room
2:30	Break-out--Discussions	
	A. Discussion of 1:30 Session, Orrin Gould, Discussant	474 PB
	B. Discussion of 1:30 Session, Ken Hartman, Discussant	469 PB
	C. The I.A.C. Program, Frank Affannato, Discussant	362 PB
3:30	Coffee	
3:45	Special Session 2 - "Assessment and Awareness: Key Ingredients in Teaching Effectiveness," James A. Shymansky, University of Iowa	474 PB

PROGRAM

Tuesday, June 23, 1981 (cont'd)

5:00 p.m.	Open Discussion and Review of Materials	474 PB
6:00	Dinner	
7:30-9:30	"Piagetian Applications to Classroom Teaching," Darrell Phillips, University of Iowa	474 PB

Wednesday, June 24, 1981

8:30 a.m.	Desired State of Inquiry, Glen Aikenhead, University of Saskatchewan, Canada	301 PB Commons Room
9:30	Coffee	316 PB
9:45	Break-out--Discussions	
	A. Discussion of 8:30 Session, Orrin Gould, Discussant	474 PB
	B. Discussion of 8:30 Session, Ken Hartman, Discussant	456 PB
	C. The HAP Materials, Dan Sheldon, Discussant	362 PB
11:00	Special Session 1, "Problems with Mainstreaming in School Science," Paul Retish, University of Iowa	474 PB
12:00	Lunch	
1:30 p.m.	Actual State of Inquiry and Recommendations for Future, Glen Aikenhead, University of Saskatchewan, Canada	301 PB Commons Room
2:45	Coffee	
3:00	Time for:	
	(1) Visits to Curriculatorium	362 PB
	(2) Conference, Sharing, and Small Group Conversation	
	(3) Optional Tour to West Branch (Hoover Birthplace, Presidential Library, etc.)	
	(4) Tours to Amana Colonies	
6:00	Family Style Dining at Ronneburg Inn, Amana "Dutch Treat"	

PROGRAM

Thursday, June 25, 1981

8:30 a.m.	Desired State of Biology, Rodger Bybee, Carleton College	301 PB Commons Room
9:30	Coffee	
9:45	Break-out--Discussions	
	A. Discussion of 8:30 Session, Orrin Gould, Discussant	474 PB
	B. Discussion of 8:30 Session, Ken Hartman, Discussant	456 PB
	C. USMES, Dan Sheldon, Discussant	362 PB
11:00	Special Session 1 - "Challenges & Ideas for Serving Gifted and Talented Students," Edward L. Pizzini, University of Iowa	474 PB
12:00	Lunch	
1:30 p.m.	Actual State of Biology and Recommendations For Future, Rodger Bybee, Carleton College	301 PB Commons Room
2:30	Break-out--Discussions	
	A. Discussion of 1:30 Session, Orrin Gould, Discussant	474 PB
	B. Discussion of 1:30 Session, Ken Hartman, Discussant	469 PB
	C. Energy Education Modules for School Science, Doris Simonis, Discussant	362 PB
3:30	Coffee	474 PB 469 PB 362 PB
3:45	Special Session 2 - "Factors That Should Affect Curriculum, Robert E. Yager, University of Iowa	474 PB
5:00	Open Discussion and Review of Materials	474 PB
6:00	Picnic, Robert Yager's Home	330 Highland Drive

PROGRAM

Friday, June 26, 1981

8:30 a.m.	Desired State of Science/Technology/Society, Joe Piel, State University of New York	301 PB Commons Room
9:30	Coffee	316 PB
9:45	Break-out--Discussions	
	A. Discussion of 8:30 Session, Orrin Gould, Discussant	474 PB
	B. Discussion of 8:30 Session, Ken Hartman, Discussant	456 PB
	C. OBIS as Modular Material for K-12 Science, Jim Spevak, Discussant	362 PB
11:00	Special Session 1 - "Twenty-five Years of New Science Curricula: A Look at Their Effectiveness," James A. Shymansky, University of Iowa	474 PB
12:00	Lunch	
1:30 p.m.	Actual State of Science/Technology/Society and Recommendations for Future, Joe Piel, State University of New York	301 PB Commons Room
3:00	Graduation and Farewell	301 PB Commons Room

Eagle, Want a Cracker?

David P. Butts
The University of Georgia
Athens, Georgia

Four comprehensive data bases have emerged which constitute an extremely rich resource for science education.

1. "The Status of Pre-College Science, Mathematics and Social Science Education: 1955-75" (Helgeson, et al., 1977).

2. "Case Studies in Science Education" (Stake & Easley, 1978) which was an intensive study of what goes on in schools and science classrooms.

3. "1977 National Survey of Science, Mathematics and Social Studies Education" (Weiss, 1978) which collected data on materials, practices and the leadership in science education.

4. The OE funded project, the National Assessment of Educational Progress (NAEP), has completed its third and by far most comprehensive assessment of science knowledge, skills, attitudes and educational experiences of precollege students, based on a broad set of objectives recently developed by NAEP.

Based on this data the typical elementary school science experiences of most students are:

1. At best very limited.

2. Most often taught at the end of the day, if there is time.

3. Taught by teachers who have little interest, experience or training to teach science.

4. Taught with no hands-on activities. Although some limited equipment is available, it usually remains unused.

5. Taken from textbooks selected by committees of teachers at the schools or based on teacher-prepared worksheets.

6. Characterized by reading and memorizing some science facts related to a concept too abstract to be well understood by the student but selected because they are "in the book."

These data also have sobering descriptions of what happens if representative teachers want to change and update their science teaching.

1. Chances are two out of three that no one is designated in the school or school district to provide any suggestions or new techniques or materials.

2. Unless teachers are in the 10 to 30 percent who have heard of the NSF-developed curricula, they will not even know they exist.

3. If they do know about one of the programs and decide to try it, funds may be so limited that the equipment required to support the program cannot be purchased.

4. Furthermore, the pressure of the administration and parents to return to a greater emphasis on the basic skills and discipline gives little incentive to make any greater efforts to teach science.

The effect of the "back-to-basics" emphasis is but one example of ways in which this pressure exists.

1. The teaching of elementary science is not so well established that it can exist independent of the influences of the school patrons, the administration, changing enrollments, budget decisions, or teacher interests and professional preparation.

2. None of these elements directly prevents the teaching of elementary science.

3. But, in the days of more demanding priorities, each of these contextual factors often results in a reduction of the quality of the science being taught.

4. It might be said that "nothing works directly against the teaching of science in the elementary schools--but, unfortunately, neither is anything working to enable it to exist.

But what should we have--the desired state of health of science in the elementary school? Four clusters of goals were identified by the Project Synthesis staff.

1. Personal Needs. Science education should prepare individuals to utilize science for improving their own lives and for coping with an increasingly technological world.

2. Societal Issues. Science education should produce informed citizens prepared to deal responsibly with science-related societal issues.

3. Academic Preparation. Science education should allow students who are likely to pursue science academically as well as professionally to acquire the academic knowledge appropriate for their needs.

4. Career Education/Awareness. Science education should give all students an awareness of the nature and scope of a wide variety of science and technology-related careers open to students of varying aptitudes and interests.

Thus, with these discrepancies between where we <u>should</u> be and where we <u>are</u>, six specific recommendations were generated by Project Synthesis.

However will we. Can we? or Should we?

Are we parrot people or eagle thinkers?

Are we running shy of eagles and running over with parrots?

Will we be content to sit safely on our school perches and repeat our warm fuzzy words? Are we fast becoming over-populated with bright-colored birds having soft bellies, big beaks, and little heads?

What would help balance things out would be a lot more keen-eyed, wide-winged creatures willing to soar out and up, exploring the illimitable ranges of the excitement of school and science...then after a brief report on their findings they'd leave the nest again for another fascinating adventure?

Parrot people are much different from eagle thinkers. They like to stay in the same cage, pick over the same pan full of seeds, and listen to the same words over and over again until they can say them with ease. They like the company too. Lots of attention, a scratch here, a snuggle there, and they'll stay for years right on the same perch. You and I can't remember the last time we saw one fly. Parrots like the predictable, the secure, the strokes they get from their mutual admiration society.

Not eagles. There's not a predictable opinion in their wings! They think. They <u>love</u> to think. They are driven with this inner urge to search, to discover, to learn. And that means they're courageous, tough-minded, willing to ask the hard questions as they bypass the routine in vigorous pursuit of excellence.

So then, which will it be? If you like being a parrot, stay put. But if you like being an eagle at heart, are you on a perch? Do you have any idea how greatly you're needed to soar and explore? Do you realize how out of place you are inside that cage? Even though others may not tell you, eagles look pretty silly stuck on a perch picking over a tasteless pile of dried seeds.

After all have you ever heard anybody ask, "Eagle, want a cracker?"

Accomplishments and Needs in Science Education

Robert E. Yager
Science Education Center
University of Iowa

The NSTA Accomplishments and Needs study was divided into four major sections. These included 1) a setting and a point of departure for the discipline of science education, 2) the aims for science education, 3) an analysis of the current status of science education with a focus on the accomplishments, and 4) recommendations for future actions for meeting needs in science education.

The interdependence of science and society was identified as the appropriate setting for any consideration of science education. There is now agreement that science education is and of itself a young discipline concerned with the interface of science and society. It is concerned with the interpretation of science to society, especially learners; it is equally concerned with interpreting and studying the effects of society upon science. This setting for an analysis of the accomplishments and needs for science education in the 80's is new--at least to the extent that there is agreement among all levels and functions of the current leadership. There was strong agreement among many groups that a consideration of current societal problems and issues should provide the most significant influence upon science teaching at all levels for the 1980's. Such a frame of reference provides new meaning for the initial input in defining general objectives for curriculum and instruction with Tyler's model.

Helgeson, Blosser, and Howe reported that the goals of secondary science education were in major transition in 1977, the time of their NSF Status report as viewed from an analysis of the research literature. The NSTA analysis team agreed that goals were in transition when the working draft

was prepared. The leadership in science education in 1980 generally agreed that significant transitions were occurring. The only group where fewer than half the sample agreed was the teacher educators (AETS membership). Supervisors and researchers were most emphatic concerning their perceptions of change in goals.

The science education leadership was in general agreement as to the direction for such changes in goals. Most saw a focus on the science and society interface, the use of science in daily situations, value and ethical dimensions for science, and a focus on problems and the future as new kinds of emphases for school science.

While the period of transition and general agreement as to the nature of such new goals were noted, many among the leadership emphasize the continued importance of basic concepts and central process goals. There was general agreement that the current situation with respect to goals was not a major disconformity with the immediate past. In fact, there was general agreement that the goals of science education have been fairly stable among advocacy groups for the past forty years. There exists a seeming paradox. Goals have been (and to some extent are) stable and yet we are in a major period of change with respect to goals. There is also strong agreement within the profession that change with respect to all aspects of science teaching is desirable and to be expected. Change with respect to goals, curricula, and teaching strategies are inherent to science education much as change is inherent to science itself. In a sense, there is agreement that the curricula/instruction model proposed by Tyler represents a continuous process.

The analysis of the current status of science education suggests

the importance and success of the science curriculum efforts of the 60's. There is general support for this notion of continuing needs with respect to staff development while suggesting that the NSF efforts of the 60's did little with respect to changing teacher behavior. They did expand the subject matter competency of teachers and provided familiarization with newly developed materials. The importance of the teacher in the teaching/learning process was noted and emphasized.

Several important situations are identified as important considerations as one analyzes the current situation and reviews the accomplishments and failures of the immediate past. Some of these factors include major shifts in population in the U.S., major decline in the support for science instruction (and schooling in general), enrollment declines in school and in science courses, a focus on accountability and competency-based programs, students vastly different from those of previous times, and teacher unionization. Such sociological/societal factors seem more important than ever before in discussing the current situation in science teaching--both as to the accomplishments and continuing needs.

The major portion of the accomplishments and needs report was concerned with specific recommendations for the future. Twenty-five specific recommendations were selected for use in studying the level of agreement among the current leadership in science education for specific actions. Generally there was strong support for the recommendations with slight variations in terms of support among various groups of teachers, supervisors, teacher educators, and researchers.

Some of the specific accomplishments in science education during the past two decades which were identified include:

1) Major involvement of the scientific community in defining the disciplines of science, in interpreting latest discoveries that are important as preparation for future living, in participating as a part of curriculum development teams.

2) New views of science education that include philosophical, historical, sociological, technological, and humanistic dimensions; recognition that these new views are as valid as organizers for learning experiences as are content and process schemes.

3) National concern for and interest in better science experiences for America's youth; renewed interest in science for all people.

4) Development of new materials which can be adapted to local situations; new instructional strategies with model materials to implement them.

5) Massive efforts to affect science curricula and teacher inservice programs.

6) Excellent preparatory sequences to enable students to prepare for advanced careers in science and technology.

7) Improved materials and facilities for appropriate science instruction.

Some of the major needs for future years include:

1) A new conceptualization of science education as a discipline, a reformulation of goals to meet the needs of a new society.

2) Inservice programs to assist professionals with implementing programs consistent with new goals.

3) Continued curriculum development to assure models for implementing new philosophy and new teaching strategies.

4) New programs for assessing all aspects of instruction and learning to provide information for planned changes and improvements.

5) New cooperative enterprises involving all segments of government, industry, and community groups as well as persons from all levels of the professional science education community.

6) New support systems, including personnel, learning centers, and communication links, to encourage change and professional growth.

7) New philosophical bases for research in order to test the validity of new conceptualizations and new directions.

Desired and Actual States of Physical Science Education

Ronald D. Anderson
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Boulder, Colorado

INTRODUCTION

The physical science group of Project Synthesis, an NSF-funded project to review U. S. science education, prepared a description of the desired states of physical science education in secondary schools, prepared an analysis of the actual states of this education based on four national data sources, and determined the discrepancies between these desired and actual states.

The desired states of physical science education were based on a set of value judgments that included the following: (1) education in science should be provided for all students, (2) there should be a balance in the science content of the curriculum, (3) this physical science education should be responsive to societal issues, e.g., energy needs and the rapid spread of information-processing and telecommunications, (4) it should give attention to science-related personal needs, and (5) "inquiry teaching" should have a significant role. Value judgments such as these are reflected in the conceptual framework which was employed for categorizing the goals of physical science education. They included goals pertaining to (1) student's personal needs, (2) science-related societal issues, (3) basic science knowledge, and (4) career preparation. Desired states also were delineated with respect to the curriculum, teacher behaviors, etc.

These desired states were used as a "grid" for examining data which describe the actual condition of physical science education in the U.S. This process enabled the participants to examine the data on actual

conditions in an objective manner without being influenced by the participants' value judgments and simultaneously allowed them to compare the desired and actual states and arrive at a description of the discrepancies that exist. In other words, the desired states delineated ahead of time caused the participants to identify particular information from a description of actual conditions and highlight that for presentation to various audiences. As a result of these deliberations, the following four items seem particularly relevant:

1. Physical science is not a significant part of general education in senior high schools. The typical general education student in senior high school takes no physical science. The overwhelming majority of students taking senior high school courses in the physical sciences are college preparatory students rather than general education students. Less than 40% of senior high school take chemistry, and less than 20% take physics. In contrast to these college preparatory students, the general education student's education in physical science ends in junior high school.
2. Physical science in junior and senior high schools gives almost exclusive attention to basic science knowledge to the exclusion of the application of this knowledge to students' personal needs, science-related societal issues, or career preparation.
3. The science curriculum is textbook-bound. In other words, once a particular textbook is adopted for a course, the only decisions remaining as to what will be taught are a matter of selection from that book; significant additions to its contents are not made. This condition is related to number two above in that the widely-

used textbooks give almost exclusive attention to basic science knowledge to the exclusion of the more applied aspects mentioned above.

4. The teacher plays the key role in making these educational decisions. In other words, teachers decide which textbook will be used and by these decisions determine what the content of physical science in the secondary schools will be. Decisions made in this regard, of course, also determine to a large extent who will take science.

Recommendations for Physical Science Education

Based on the Project Synthesis analysis of the desired and actual states of U. S. physical education in secondary schools, the following set of recommendations is presented.

1. The goals of physical science education should be broadened to include all four goal clusters (personal needs, societal issues, basic knowledge and career preparation) for all students from kindergarten through twelfth grade. Implementation of this recommendation will require major changes in senior high school course offerings and enrollments if this education is to be provided for all students rather than just the college preparatory students.
2. Existing science programs should be modified and new ones developed as needed for reaching all four sets of goals. At the junior high school level this means modifying science courses so all four sets of goals are given attention. At the senior high school level there is a similar need in physics and chemistry courses for more

attention to personal needs, societal issues, and career preparation. It also means the introduction of new physical science courses at the senior high school level to provide for the needs of the general education student.

3. New pre-service and in-service teacher education programs are needed if recommendations one and two above are to be implemented. One important goal of these programs, among others, is to encourage a broader set of goals. It is not limited to preparation of students for the next level of schooling.
4. Evaluation activities in schools should be modified to reflect all four sets of goals. The testing programs employed in schools substantially affect educational practice in the classroom. What is tested is what is taught. Modification of existing testing programs has the potential of encouraging changes in classroom practice.
5. Additional research should be conducted on the issues of goals and implementation of educational change.

The previous recommendations reflect two major issues faced by science education today. The two issues are: "What should be the goals of science education?" and "How can change in science education practice be implemented?" There is no clear consensus as to what goals should be pursued in science education in the immediate future. Even if we had this consensus, our recent history does not give much hope that we know how to implement the desired changes. Researchers and leaders in science education have many challenges before them.

ISIS Curriculum Project Summary

Jan Wielert
Science Education Center
University of Iowa

INTRODUCTION

The ISIS program consists of a series of self-contained paperback modules dealing with aspects of Biology, Chemistry, Physics, and Earth Science. Modules are self-paced and feature optional Excursion and Advanced activities which allow for a wide range of student ability levels. Reading levels are generally 6th and 7th grade, and the texts are profusely illustrated. The ISIS program is available through Ginn & Co.

Although this program is generally considered for middle school or 9th grade use, it has been successfully introduced into the high school curriculum as a "general science" course for low-ability mainstream students as well as mainstreamed EMR, LD, and ED students. The curriculum developed by Jan Wielert and Laneh Johnston at Neenah High School, Neenah, Wisconsin, is built around three required units: Birth and Growth, Heart Attack, and Packaging Passengers. Students at 11th and 12th grade were invited to participate in the course beginning in 1977-78. Since that time the program has been continually taught with a variety of teachers. Students' response has been quite positive and teachers have reported good feelings about what goes on in the classroom.

An unusual aspect of this program is the introduction of CPR training for all students as part of the Heart Attack unit. In past years about one-half of all students enrolled in the class have received certification in Basic Life Support from the Heart Association. Standards for certification were not sacrificed to achieve this result.

The ISIS program provides activities which relate to students' interests in a manner which makes learning enjoyable. The self-paced nature of the course provides for progress of students of all ability-levels. The use of Advanced and Excursion activities allows the teacher to tailor the learning experience to the ability of the student. The modular nature of the activities allows implementation on one module in an existing curriculum. Approximately thirty modules are currently available. They cover a wide range of topics and provide adequate material in Biology and Physical Science for a year-long curriculum.

A five-page article on the Neenah High School Program is available from Mr. Jan S. Weilert, Science Education Center, The University of Iowa, Iowa City, Iowa 52242. ISIS materials are available for examination in the Science Education Center's Curriculatorium.

Safety and School Science

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Ames, Iowa

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INTRODUCTION

School science laboratories should be active sites of learning. They may also be areas of potential danger from fire, explosives, caustic chemicals, poisons, noxious fumes, and projectiles.

Science teachers are charged with the responsibility of establishing an environment in which students shall have relevant, practical science experiences. In addition, certain segments of the subject matter will require that students develop particular attitudes, knowledge, and skills. Inevitably students will periodically be exposed to potentially dangerous situations.

The courts have held that a teacher is liable for damages only if it can be proved that a teacher has failed to take "reasonable care" or has acted in an illegal manner.[1]

In an effort to increase the science teacher's awareness of potential danger and responsibilities, the Iowa Department of Public Instruction (DPI), the Iowa Council of Science Supervisors (CS^2), and Iowa State University (via a National Science Foundation Grant) have developed a science safety manual entitled Better Science Through Safety.

Procedures

In the Spring of 1978, a twelve member Iowa Science Safety Task Force was identified with representation from the DPI, Area Education Agencies (AEA's), school districts from large cities, colleges/universities, and

classroom teachers. Consultative assistance was provided by representatives from Employers Mutual Insurance Company, Environmental Health and Safety Department - Iowa State University, National Animal Disease Laboratory - Ames, Safety Education - Iowa State University, and a private attorney. In addition, the following agencies provided assistance in dealing with chemical hazards: Iowa State Fire Marshal's Office, Iowa Office of Disaster Services, University of Iowa Hygienic Laboratory, and the Iowa Department of Environmental Quality.

Utilizing materials and concepts developed primarily by the National Institute for Occupational Safety and Health (NIOSH) and the Council of State Science Supervisors (CS^3),[2] an outline was developed for the Safety manual. Eleven major components were chosen to be incorporated into the manual. These eleven components were:

Introduction and Statistical Background
Legal Liability
Eye Protection and Eye Care
Aspects of Biological Safety
Aspects of Chemical Safety
Aspects of Physics Safety
Field Activities
Student Research (Projects)
Physical Plant and Facilities
Science Safety for Handicapped Students
Accident/Incident Reporting Systems

Results

The completed manual, Better Science Through Safety,[3] contains eleven major sections with four appendices:

Preface
Introduction and Statistical Background
Legal Liability
    Case Studies
Eye Protection and Eye Care
Aspects of Biological Safety
    Table of Contents
Aspects of Chemical Safety
    Table of Contents
Aspects of Physics Safety

Field Activities
Student Research (Projects)
Physical Plant and Facilities
Science Safety for Handicapped Students
Accident/Incident Reporting Systems
List of Tables
List of Figures
Appendices
    Check Lists
        Legal Liability
        Eye Protection
        Eye Care
        Biological Aspects
        Chemical Aspects
        Physics Aspects
        Field Activities
        Student Research
        Physical Plant and Facilities
        Handicapped Students in Sceince
        Accident/Incident Reporting
    Eye Protectors
    Explosion-Safe Refrigerators
    Safety Equipment

The developed book may be purchased from Iowa State University Press, South State Avenue, Ames, Iowa 50010.

Elementary Safety Manual Development

An Elementary Safety Task Force has been named to develop a science safety manual for elementary teachers. The manual is in the final stage of draft number one. A procedure similar to the one used to develop the secondary manual is being used. The 12 major sections of the planned manual are listed below:

1. ACCIDENT STATISTICS
2. LEGAL LIABILITY
3. EYE PROTECTION & EYE CARE
4. PHYSICAL SCIENCES
5. CHEMICALS AND HANDLING
6. LIFE SCIENCES
7. OUTDOOR ACTIVITIES
8. STUDENT PROJECTS
9. SCIENCE SAFETY FOR HANDICAPPED LEARNERS
10. PHYSICAL PLANT FACILITIES
11. FIRE PROTECTION AND CONTROL
12. FIRST AID

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Assessment and Awareness: Key Ingredients in Effective Science Teaching

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There is an intuitive notion among science teachers and considerable research evidence to suggest that key interactive skills are critical to eliciting certain responses from students and fostering learning in the classroom. The questioning skills or wait-time patterns of the teacher, for example, are some of these critical interactive skills. Are there other key ingredients in effective science teaching? Can critical skills be isolated and improved upon? These are some of the questions which were addressed in the session.

Activities and discussion focused on systematic observation techniques applied to classroom interactions. Using systematically coded data describing teacher-student interactions, teachers are made aware of the behaviors and techniques they use and can begin to assess areas of strengths and weakness in their teaching methods.

Participants observed a role-playing episode and tried their hand at collecting objective information about the actor's behavior. The observations were analyzed for their detail and prescriptive potential. The implications of systematically collected, low inference observation data for effective science teaching were discussed.

A Report on the Inquiry Seminar

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A. Desired States

Shortly after 'inquiry' was defined ("a process by which we seek information or understanding") and various inquiry strategies were mentioned (values clarifying, scientific inquiry, general problem solving, and decision making), the group got their hands wet and sticky inquirying into why carbonated drinks fizzed when poured over ice. Being a bright group, the participant's own behavior exemplified characteristics of inquiry. These included (a) unique individual approaches (standing back to theorize versus leaping ahead to find out), (b) giving high priority to the use of evidence and being rational (a touch of realism--some participants found productive creative consequences to momentary irrationality as well), and (c) customs of conduct or an ethos to hold as a goal (for example, open-mindedness, criticalness, and integrity).

Certain events that occurred during this inquiry helped to define the desired state for student outcomes. Desired student outcomes were described within the familiar four goal clusters: personal, social, academic, and career. Participants experienced events that demonstrated:

a. Strategies of inquiry, of which scientific inquiry is one.
b. Safeguards and customs of inquiry; different participants expressed different aspects of the ethos of inquiry.
c. The nature of scientific inquiry; understanding from an outsider's perspective, what scientific inquiry is about.

d. Processes or Methods of science; doing inquiry; that is, seeing a problem and seeking solutions; observing and measuring; interpreting data and forming generalizations; building, testing, and revising models and ideas.

A detailed description of the desired student outcomes was cited; Project Synthesis Inquiry Report, Phase I, October 1978.

In addition to the desired state of student outcomes, other desired states of critical aspects of teaching were discussed. For instance, certain teacher characteristics seem desirable for teaching inquiry. These were illustrated by analyzing Aikenhead's performance at instigating and sustaining the group's inquiry into fizzing pop.

B. Actual State of Inquiry and Recommendations for the Future

Perhaps the participants' greatest concern was with the actual state of inquiry teaching, particularly with the barriers that appear to mitigate against including inquiry in one's repertoire of teaching methods.

There is good news and there is bad news. The good news is that there are instances of excellence in inquiry teaching. The bad news is that these instances are minuscule, and overall, inquiry teaching hardly occurs.

Perhaps the overwhelming barrier for many teachers is their perception that classroom control would be reduced by inquiry teaching. Classroom control includes both intellectual control (control over the ideas children come up with) and behavioral control (control over the overt behavior).

A reduction in behavioral control probably reflects poor teaching. However, a reduction in intellectual control must be a characteristic of inquiry teaching.

A point worth remembering is that a teacher can maintain classroom control in an inquiry setting by maintaining behavioral control, while simultaneously nurturing low or indirect intellectual control.

Another barrier to inquiry teaching concerns a teacher's background experience. Very few teachers have experienced an inquiry approach themselves. It is simply unreasonable to expect a teacher to teach in a way she has not experienced herself. The lack of experience in inquiry dissuades many from using inquiry themselves.

Furthermore,the customs or ethos of inquiry conflict with socialization goals held by many communities. When communities do not support an inquiry mentality in their youngsters, communities will not support inquiry teaching.

Teaching science is viewed traditionally as finding out the facts. Lab equipment and "hands-on" activities are seldom used for inquiry, but instead they are used for telling and showing the facts. As a result, science is generally taught as a "rhetoric of conclusions".

How do students fare when their understanding of inquiry is assessed? The NAEP data harbored few surprises in their negative results. The positive accomplishments that did appear tended to reflect a superficial understanding of inquiry.

In summary, the actual state of inquiry does not even come close to matching the desired state of inquiry. This presents a dilemma. What to do? Anything tried in the past (developing new curricula and carrying out institutes) has been insufficient in encouraging much inquiry in school science.

One way out of the dilemma was proposed by the Project Synthesis

Inquiry Group. They recognized that inquiry is only a reasonable education practice in communities that would support inquiry teaching. The degree of inquiry in classrooms would have to be consistent with, and bounded by, the degree of community support. Another natural boundary is the student himself. Inquiry makes demands on students; for instance, it requires active learning, thinking, and a tolerance for uncertainty. Therefore, inquiry is only a reasonable education practice to the degree to which it is consistent with a student's characteristics and abilities. The relevancy of inquiry to a student's career goal is another natural boundary. The Project Synthesis Inquiry Group recommended that traditional ideas about educational goals be reformulated. Specifically they recommended that a child be given a "Student Profile for Inquiry Competencies". The actual competencies (drawn from the desired student outcomes) would be affected by the natural boundaries described above. In other words, the inquiry goals set for a child would be determined by the community he lives in, his learning abilities and personal characteristics, and his career goals. By establishing individual Student Profiles for Inquiry Competencies, one is defining desired outcomes in a realistic way, rather than in a naive idealistic way.

Mainstreaming and the Science Educator

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Division of Special Education
University of Iowa

Mainstreaming to the science educator is a concept that is no different than all other educators. Initial response usually is, "What will I do with a student with special needs?" At the secondary level not only are we concerned as to what we will do, but how it will affect other students and the materials we need to get across.

To argue with the mainstreaming concept is probably fruitless and more importantly not what most educators really want to do. Rather the antagonism centers around the dropping of students in classes where the teachers receive no assistance and have little idea of curricular adjustments needed.

With this in mind, I would suggest the following strategies prior to the placing of special needs students in regular classes:

1. A comprehensive update of all teachers on the strengths and weaknesses of special needs students.
2. The placement of library materials that are useful to the teacher with teaching special needs students.
3. A standard school-wide policy whereby special education teachers are assigned the responsibility to assist regular classroom teachers with the mainstreamed students.
4. Extra credit and extra pay for those teachers who spend extra time outside of class to get materials and resources to teach the special needs students.

A further consideration needs to be focused upon the training of teachers. Pre- and inservice needs to many regular classroom teachers center

upon a lack of awareness regarding the educational needs of special populations. Therefore training programs must incorporate teaching and field experience with these students. This will enable teachers to have a working knowledge of resources and needs of many students.

Lastly, and most importantly, to the regular classroom teacher (in this case, science teachers) has been the reluctance to teach based upon prejudicial attitudes, special needs students. This has also been complicated by a general feeling of having to teach a science core in a traditional manner with no thought given to individual needs of students in classes. Change must occur that allows curriculum to move based upon the real needs of the students once they are out of school. In the case of many special needs students, this calls for a functional curriculum that will assist them in coping with nonschool atmospheres.

Using educational resources combined with a will to do the job, the science teacher will/can provide excellent education for all of these students. This excellence can only be accomplished if special educators and administrators understand the expanded roles necessary to accomplish excellence in teaching.

The Future of Biology Education

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There is every indication that this is an age of major change. A major document supporting this assertion is The Global 2000 Report to the President. I quote the major findings and conclusions:

> "If present trends continue, the world in 2000 will be more crowded, more polluted, less stable ecologically, and more vulnerable to disruption than the world we live in now. Serious stresses involving population, resources, and environment are clearly visible ahead. Despite greater material output, the world's people will be poorer in many ways than they are today."
>
> "For hundreds of millions of the desperately poor, the outlook for food and other necessities of life will be no better. For many it will be worse. Barring revolutionary advances in technology, life for most people on earth will be more precarious in 2000 than it is now -- unless the nations of the world act decisively to alter current trends."

These conclusions force upon us the necessity for change. Because of the central role of science and technology in the social problems cited in the above quotation, it seems that education relative to science and technology has a clear and compelling need to change.

Based on the necessity to change I suggest the following general policy for science education. This policy can in turn be interpreted and modified by science educators in light of their own unique circumstances.

> Science education programs should include objectives that will (1) fulfill basic human needs and facilitate personal development; (2) maintain and improve the physical and human environment; (3) conserve and efficiently use natural resources; (4) develop greater community at the local, regional, national, and global levels.

The future of biology education will change in many important ways. Some of the project changes for the period 1980 to the year 2000 include:

1. Goals related to science in society will be the organizational core of the curriculum.

2. Scientific and technological knowledge will be presented in the context of science-related social issues.
3. Scientific methods will be presented as inquiry into personal, environmental, and social problems to acquire information for decision-making.
4. Laboratory activities will provide opportunities to solve problems, to learn inquiry processes (both reductive and holistic) and to develop decision-making skills.
5. Science programs will be determined by teachers with the assistance from curriculum developers, supervisors, national organizations, and textbook publishers.
6. Textbook, laboratory simulation games and other media and resources will be important components of the science education program.
7. The interdependence among science, technology and society will be stressed in science education programs.
8. Science and technology will be presented as an ever changing body of knowledge and its applications, having important influences on society. Updating and using knowledge for decision-making will be underscored.
9. Science education will be interdisciplinary.
10. Career information will be directed to multiple scientific and technological occupations for all persons.

Science teachers are in a position to initiate the changes suggested in this summary. We cannot depend on outside agencies to bring about changes for us. We must be responsible for science education in the future, and the time to prepare for the future is now.

Challenges & Ideas for Serving Gifted and Talented Students

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The presentation focused on Lateral Thinking, the generation of new ideas, to enhance creativity. The purpose of thinking is not to be right, but to be effective. Being effective does eventually involve being right, but there is a very important different between the two. Being right means being right all the time. Being effective means being right only at the end.

Education is soundly based on the need to be right all the time! Throughout education, one is taught the correct facts, the correct deductions from them and the correct way of making these deductions. One learns to be correct by being made very sensitive to what is incorrect. One learns to apply judgment at every stage and to follow up this judgment with the "no" label - no, this is not so, this cannot be, you are wrong, this would never work, etc. The need to be right all the time is the biggest bar there is to new ideas. It is better to have new ideas and for some of them to be wrong, than to be always right by having no ideas at all.

The presentation focused on the only available method for changing ideas - conflict and how conflict works. This is the method of science which is always seeking to generate new information to upset the old ideas and bring about the new ones. The shortcomings of an educational system based on the assumption that one only has to collect more information to sort itself into useful ideas was discussed. A short discussion on the sequencing of information and how the mind is a pattern-making system provided the evidence on rationale for the necessity of lateral thinking.

Demonstrations and activities were utilized to reinforce the concept that greater amounts of time should be spent in activities that involve challenging assumptions, brainstorming, fractionalization and reversal which lead to the generation of new ideas and create an atmosphere conducive to creative thinking.

The Status of Biology Education

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Is biology education meeting present social challenges? The answer to this question is no. The bases for the answer are found in a number of contemporary reports, documents and articles. Project Synthesis is the review effort that forms the primary bases of this summary.

There are a number of issues confronting contemporary biology education. These issues include: the basics movement, budget cuts, career education, competency based curricula, accountability of educators, inappropriate curriculum programs, equality of educational opportunity, declining enrollments, outdated facilities and equipment, inadequately qualified biology teachers, and discipline problems in the science classroom.

These problems can be analyzed from three levels -- practice, programs and policies, and purpose. The first level is the most concrete. There is little question about the immediacy and importance of the problems mentioned. However, experience shows that improvement in biology education requires more than an increase in budgets. This brings us to the second level -- programs and policies. While it is clear that attention must be paid to the development of new programs and the implementation of policies (e.g., PL94-142, equal educational opportunity) here again, we find a situation where there is more required of biology educators. Logic leads us to the third level -- purpose. This is the most basic level. At this level we encounter the basic educational questions - "what are the goals of biology education?" Agreement among biology educators on these goals provides a common purpose. The purpose is in turn translated to programs, policies, and practices aligned with the unique situations within which biology educators find themselves. Suggesting that we need new purposes, new goals, and new directions is <u>not</u> to argue that

all other problems can be ignored. They cannot be ignored. We must work at all three levels, but we must work especially hard to identify a new direction.

There are some specific and critical points concerning science teaching that should be considered in our search for new directions.

1. Science education is in a period of relative low national priority.
2. Scientific knowledge in its various forms (facts, concepts, principles, conceptual schemes) is the goal of science instruction.
3. The textbook is the basis of science instruction (90% of science teachers use a textbook 90% of the time).
4. The science teacher determines the course goals and curriculum usually through the selection of a textbook.
5. The science teacher determines the educational tone, tactics, and techniques for the students.
6. Lecture/Demonstration is the prevalent mode of science instruction.
7. Science education is at a genuine turning point in its history.

What can science teachers do? There are several rather specific steps that can be made within each school and/or classroom.

Evaluate the purpose, programs, policies, and practices of your school. Set a perspective of what science teaching ought to be like in your school/classroom. Then determine the actual status of your program. Take a very close look at your goals, practices, curriculum, etc. After these two steps you are in a position to determine any discrepancies between what you think ought to be and what actually is your science program. Then the task of ameliorating the discrepancies begins.

Biology educators have a very serious task facing them that must be initiated in the 1980's. Indeed, the problems are vast and the perspective from any single individual seems overwhelming. But, little steps can be made through ways and means within the control of biology educators themselves.

We must all realize we are in a position to bring about the changes required for a biology education that will meet present -- and future -- social challenges.

Energy Education Modules for School Science

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Discoveries of concentrated, mined fuels and of ways to convert their energy from one form to another were powerful tools for the survival, advancement, and comfort of the human race. However, rapid use of these buried treasures (coal, oil, gas, and uranium) has been a mixed blessing. Air, water, and ground contamination have often been accelerated past the rates of natural cycles of renewal. Yet many people thrive in areas where energy consumption is relatively high, more people than wholly natural energy systems can support in the "standard" of western civilization. Population growth combined with higher aspirations of people in developing nations means even greater world energy consumption each year is likely.

We seem to be approaching natural limits to the capacity of Earth to maintain unrestricted growth of people and material goods. A transition in the course of energy consumption is inevitable and therein lies a challenge to educators. An "Age of Limits" is an exciting challenge if seen as an opportunity to choose and to plan for a future different from the immediate past, to experiment with alternatives in lifestyles and technologies, to develop new outlets for human adaptability and inventiveness, and to write the "Operating Manual" for planet Earth that will keep her hospitable to life for millions more years.

The framework used in free or low-cost materials like the DOE Solar Energy Project, Energy and Man's Environment, Iowa-Developed Energy Activity Samplers (IDEAS), and NSTA/DOE Project for an Energy-Enriched Curriculum is the infusion model. Recognizing that various energy topics fit well into existing disciplines, developers hope that activities will be chosen by individual teachers to complement and extend or to bring a new perspective

to topics usually covered in the sciences, social studies, home economics, industrial arts, mathematics, and language arts. Also the activities presented usually exercise skills that teachers aim to develop.

Energy-related curricula often include interdisciplinary activities as well. Energy education is interdisciplinary because every area of human endeavor depends on energy. An emphasis on energy as the basis for every aspect of life puts a new perspective on much human knowledge and shows a "connectedness" that was not obvious before. Energy choices are not only technological ones; they are likely to have multivariate effects on personal and international economics, on the environment and its capacity to safely sustain us, on the materials our children may hope to use, and on the lifestyle options that future generations may have.

A variety of approaches is recommended for teaching about energy. Activities available can stimulate interest in the natural dynamics of the environment, provide insights on the interdependencies of people and other living things, and promote recognition of human value/choice/action synergies that will shape the future. Teachers and students can demonstrate, experiment, build, discuss, debate, survey, role-play, write, draw, research, explore, brainstorm, model, investigate, measure, evaluate, dramatize, and display progress in understanding energy and its related technology and in practicing less wasteful energy uses.

Energy flows in all directions throughout the physical world, but some of it comes to a focus in the biosphere and in the flowering of human culture. It seems natural that energy awareness should also grow by a gathering of illuminations from various sources, both practical and theoretical, and should involve many skills. Ideally, energy education will foster curricular integration, will help develop a conservation ethic, and will challenge the inventiveness and initiative of creative minds.

Factors That Should Affect the K-12 Science Curriculum

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The science curriculum is defined as the set of courses that are characterized by the textbooks teachers use for each. When the situation is studied nationally, it is apparent that relatively few textbooks are in use for a given course. For example, these textbooks are in use in over eighty percent of the classrooms in the U.S. and biology is the last experience with science for nearly eighty percent of all high school graduates.

When textbooks are analyzed, it is apparent that they are structured in a way that mirrors the various disciplines of science. Often the divisions of a given course reflect whole course titles that teachers are likely to have experienced at college. It is fair to state that school science is a reflection of college science where the primary aim is preparation for further work in a given discipline. Few college courses deal with anything other than the fundamental knowledge traditionally used to define a discipline.

Several recent research efforts, including Project Synthesis and the NSTA Accomplishment and Needs Analysis (reported earlier), point to new directions with implications for the curriculum. These include the following:

1) Emphasis upon science for academic preparation has been a major focus of the past. However, major concern for science as a means of encountering and resolving current societal problems, a means for attending to the personal needs of students, and as a means of approaching greater awareness of career potential in science, technology, and related fields suggest goals that may be far more important than the traditional goal of academic preparation for future courses.

2) Teachers are central in realizing past accomplishments, in planning local programs, in making the difference with learners. Curriculum is seen as a form of support for teachers - not something that will constrict and/or direct them. The necessity for improving teacher education programs (both pre-service and in-service) is viewed as a critical need and one where there is greatest agreement concerning the need across the profession.

3) Some of the past assumptions regarding science teaching are being questioned. These include:

a) the importance of the laboratory - (a redefinition of laboratory in terms of position in the program is occurring);
b) the appropriateness of inquiry as a focus;
c) the "discipline" organization for secondary courses;
d) a two-dimensional view of science (i.e., content and process) as accurate and/or complete;
e) a focus upon science that is at the "cutting-edge" of researchers (science that is useful in the lives of learners is in evidence);
f) the necessity of science as a precursor for study at the next academic level;
g) the appropriateness of all learners learning the major ideas and the unique processes that professional scientists know and use; and
h) the more science content preparation that a teacher experiences the better the teacher.

4) Continued questioning, assessment, evaluation, and specific new attempts with goals, curriculum, teaching strategies, and support materials and personnel are improtant as a means for stimulating improvements and for solving many immediate problems. This basic "spirit of science" must be used to a greater degree in science education.

5) There is an urgency concerning the current status of science education in the United States. There is general agreement that science education must act in a concerted fashion in order that educational and societal problems might be confronted and resolved.

Several of the latest national efforts with respect to curriculum development have resulted in new materials with many basic features in common. These features of "new" science programs include the following:

DESIRED PROGRAM	ACTUAL PROGRAM
Goals:	
1. Human adaptation and alternative futures emphasized.	1. Minimal consideration given to human adaptive capacities.
2. Science-related social problems and issues as goals.	2. Marginal emphasis on society-related goals.
3. Inquiry processes unique to specific disciplines/situation.	3. Inquiry skills characteristic of a generalized model of science.
4. Decision-making involving scientific knowledge in social contexts.	4. Uncovering a correct answer to discipline-bound problems.
5. Career awareness an integral part of learning.	5. Minimal attention to careers, historical personages highlighted.
6. Value, ethical, and moral considerations of science-related problems and issues.	6. Value-free interpretations of discipline-bound problems.
Curriculum:	
7. Curriculum is problem-centered, flexible, and culturally as well as scientifically valid.	7. Curriculum is textbook-centered, inflexible; only scientific validity is considered.
8. Humankind central.	8. Humankind incidental.
9. Multifaceted, including local and community relevance.	9. Textbook controlled; local relevance fortuitous.
10. Use of the natural environment, community resources, and the students themselves as foci of study.	10. Contrived materials, kits, and classroom-bound resources; in biology use of sub-human species as foci of study.
11. Information is in the context of the student as an organism in a cultural/social environment.	11. Information is in context of the logic and structure of the discipline.
Instruction:	
12. Individualized and personalized, recognizing student diversity.	12. Group instruction geared for the average student and directed by the organization of the textbook.
13. Cooperative work on problems or issues.	13. Some group work, primarily in laboratory.
14. Methodology based on current information and research in developmental psychology involving cognitive, affective, experiential, and maturational studies.	14. Weak psychological basis for instruction in the sciences; behavioristic orientation.

DESIRED PROGRAM	ACTUAL PROGRAM
Evaluation:	
15. Testing and evaluation stress the use of scientific knowledge to interpret personal and social problems and issues.	15. Replication of assigned information.
16. Student evaluation is based on growth in rational decision-making.	16. Stating "current" solutions to pre-planned problems.
Teachers:	
17. Requires a change in perceptions (philosophy, rationale, belief system) of science teaching to include a commitment to human welfare and progress.	17. Philosophical perceptions not evident in practice, beyond a commitment to the disciplines of science.
18. Philosophical position influences all aspects of curriculum and teaching practices.	18. Curriculum and teaching practices largely atheoretical and routine.

Actual State of Science/Technology/Society
Recommendations for the Future

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Introduction

The science-technology-society (STS) Focus Group of Project Synthesis was charged with the task of interpreting the states of science education from the perspective of those concerned primarily with the interface of science, technology and society. This perspective is in contrast to the perspectives of specific disciplines and of scientific inquiry. The STS perspectives are not limited to considerations which grow out of work within those disciplines, but also incorporate concerns which originate from the society which is impacted by developments in science. The domain of STS does not have any one traditionally accepted definition as do the domains of physical and biological science. For that reason, the STS group spent considerable effort in the definition of the STS domain.

The definition of technology as perceived by this focus group must precede any discussion of the desired state of science programs in terms of their treatment of science-technology-society interactions. We accepted a rather broad definition of technology which includes both "Hard" and "Soft" technology. Hard technology encompasses the hardware developed for use by humans. This ranges from the first crude weapons and tools of primitive man to the most sophisticated computer. Soft technology includes the systems involved in the development and use of technological devices, as well as the systems involved in solving problems in industry and society at large, including behavior modification. Low level technology is described as the type of work which semi-skilled technicians do: wiring a lamp, changing a tire, or changing a washer in a faucet, etc.

The traffic control system in a community involves all three technologies: the lights, timing mechanisms, machines which stripe the roads, signs, roads are all hard technologies. The system which is designed to control the traffic (i.e., laws, timing sequences, maintenance schedules, procedures for the analysis and evaluation of the system) are all soft technologies. The changing of the burned-out light, installation of traffic lights, or striping of the road are all low level technologies. The impact of the entire traffic control system on individuals and society is an example of the science-technology-society interface.

The following section of the report is a statement of the desired state for the teaching of science-technology-society issues at the present time. Since there are very few organized science-technology-society courses presently being taught at the secondary school level, it was necessary for the focus group to identify and describe specific areas of concern. These areas are:

* Energy
* Population
* Human Engineering
* Environmental Quality
* Utilization of Natural Resources
* National Defense and Space
* Sociology of Science
* Effects of Technological Development

The list of topics above represents areas which are commonly identified as fitting the perspective of this focus group. They are not the only topics that could be listed and we make no claims to have listed the eight "most significant" topics. However, these topics do exemplify the kinds of issues with which we were concerned and about which we sought interpretations. From our inspection of the data, we sincerely doubt that different, but similar lists of topics

would have led to different interpretations or conclusions.

DESIRED STATE

The following desired state conditions illustrate the direction for science-technology-society in a typical school:

Goal Cluster I - Personal Needs

Science education programs should prepare individuals to utilize science for improving their own lives and coping with an increasingly technological world.

Energy

Science education programs should provide the individual with an understanding of the energy problems from a personal perspective.

Population

Science education programs should provide individuals with an understanding of their role in population dynamics.

Human Engineering

Science education programs should provide the individual with an understanding of emerging problems in the field of human engineering.

Environmental Quality

Science education programs should provide the individual with an understanding the various aspects of environmental quality and that those aspects may differ with other individuals.

Utilization of Natural Resources

Science education programs should provide the individual with an understanding of the various aspects of utilizing the earth's natural resources.

Space Research and National Defense

Science education programs should provide the individual with an understanding of the various accomplishments of space research and national defense programs.

Sociology of Science

Science education programs should provide the individual with an understanding of the sociology of science.

Effects of Technological Developments

Science education programs should provide the individual with an understanding

of the effects of both hard and soft technological developments on individuals and society in general.

Goal Cluster II - Societal Needs

Energy

Science education programs should provide the individual with the background necessary for taking responsible action on energy related issues confronting the society.

Population

Science education programs should provide the individual with the background necessary to understand and react to problems associated with population dynamics.

Human Engineering

Science education programs should provide the individual with the background necessary to develop insight into the emerging field of human engineering and its impact on society.

Environmental Quality

Science education programs should provide the individual with the background necessary to recognize the variations of the acceptable environmental quality of his/her community, state and nation, as well as to maintain or improve it.

Utilization of Natural Resources

Science education programs should provide the individual with the background necessary to recognize the societal problems involved in finding, using and conserving natural resources.

Space Research and National Defense

Science education programs should provide the individual with the background necessary to react to the problems and potential benefits to society of the national defense and space programs.

Sociology of Science

Science education programs should provide the individual with an understanding

of the sociological effects of science and technology.

Effects of Technological Development

Science education programs should provide individuals with an understanding of the impact of technological developments on society, in order to make reasonable decisions regarding their responsibilities involving these effects.

Goal Cluster III - Academic Knowledge of Science

Science education programs should insure the continued development and application of scientific knowledge by maintaining a "critical mass" of fundamental scientific understanding in the American public.

Goal Cluster IV - Career Awareness and Education

Science education programs of the community should insure the continued development and application of scientific knowledge by maintaining a continual supply of citizens with scientific expertise.

Career Opportunities

Programs of science education should provide the individual an appreciation for career opportunities in science and technology.

Career Decisions

Programs of science education should provide the individual the appropriate expertise/experience to make decisions and take advantage of career options in science and technology.

Holistic View of Science

Programs of science education should provide a broad view of science and technology to insure that the perceptions of individuals are most complete.

The Current Status of STS Teaching

With the above-stated goals and areas of concern in mind, the focus group examined the three studies funded by NSF and the one funded by the

Office of Education (OE). The three NSF studies include an extensive review of science education-related research, a component of The Status of Pre-College Science, Mathematics and Social Science Education: 1955-1975 (Helgeson, et al., 1977), Case Studies in Science Education, which is an intensive study of what goes on in science classrooms (Stake and Easley, 1978), and the 1977 National Survey of Science, Mathematics, and Social Studies Education (Weiss, 1978). The OE funded project, the National Assessment of Educational Progress (NAEP), has completed its third and by far most comprehensive assessment of science knowledge, skills, attitudes, and educational experiences of pre-college students.

The following statements are a distillation of the findings of that examination.

1. Teachers rely primarily on textbooks for their course content. Evidence for this was found in all four data sources. Teachers, students, and classroom observers all report an overwhelming reliance on science textbooks as the curriculum.
2. There is little or nothing of STS in currently available textbooks. Our group reviewed a number of widely used textbooks (as reported in Weiss, 1978), and found virtually no references to technology in general, or to our eight specific areas of concern. In fact, we found fewer references to technology than in textbooks of twenty years ago. The books have become more theoretical, more abstract with fewer practical applications. They appear to have evolved in a context where science education is considered the domain of an "elite" group of students.
3. There are very few courses which attempt to meet the STS goals or areas of concern. Those which do are, because of the elitism among school people, known by such terms as "dumb dumb physics," etc. There are materials available for technology-related courses,

but they are virtually unknown among science teachers.

4. Preparation of teachers to teach these courses effectively is essentially nonexistent in spite of the AAAS Guidelines of 1970 which urged such preparation. It appears that the science courses taken by most teachers in college are those designed to prepare specialists in science fields such as botany, physics, and geology. Such courses are generally quite theoretical and present much information within narrow disciplinary boundaries. Despite the fact that most high school students will not become specialists in scientific fields, the instruction they receive is patterned after college courses developed for specialists.
5. There is some attempt at inservice preparation of teachers and administrators, but this falls more in the awareness category than in the preparation category. Most inservice is apparently designed either to improve teaching methods or teachers' background in their discipline. Although both those goals are very important, they are unlikely to result in more emphasis on technology in the curriculum.
6. National Assessment found that there is a very low level of knowledge regarding these areas. For example, only 12 percent of seventeen-year-olds knew that most plastics come from petroleum, and only 3 percent were aware that the U. S. infant mortality rate is worse than that of most western European countries. Achievement on a number of National Assessment items in the STS domain was quite disappointing, and generally below achievement on more "traditional" items.

From the above findings, it seems safe to conclude that science education has accepted very little responsibility for education in the STS domain.

Virtually every aspect of the science education enterprise has systematically avoided attention to topics such as those in the previous section of this report. Actually, as our society has become more technologically oriented, our science curriculum has become less so. Our group is deeply concerned by this state of affairs.

The Effects of New Curricula on Student Performance

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Science Education experienced a growth in the twenty year period following the launching of Sputnik by the Soviet Union on October 4, 1957 that can be described only as phenomenal. Numerous "alphabet soup" science curricula were developed in this period in response to public outcries that students were ill-prepared to compete with the Russians, especially in the math and science areas. Morris Shamos, noted physicist, science educator, and curriculum developer, estimated that five billion dollars were spent to improve K-12 science instruction during the fifteen years following Sputnik One.

New science programs developed during the sixties purported to emphasize the nature and unity of science--learning science from a scientist's perspective using inquiry, investigation, and exploration. This was viewed in contrast to the traditional approach in which science was presented as a collection of facts, laws, theories, applications (Haney, 1966; Klopfer, 1981; Schwab, 1963). New science curricula quickly came to be known for their process orientation in learning, challenging the fact orientation of the traditional courses.

Exactly how much fact-to-process reorientation occurred in K-12 science instruction as a result of the new curriculum movement is difficult to know. Changes in instructional strategies were mostly assumed but seldom measured. The impact of new science curricula on student performance, on the other hand, was studied widely in the post-Sputnik era. The extent of this impact was the subject of this presentation.

Examined one by one, it is difficult to extract a convincing argument for or against the effectiveness of new science curricula measured in terms of student performance. Some studies have shown new programs producing dramatic gains

on affective and/or cognitive measures; others have shown just the reverse. Any attempt to formulate definitive statements on the impact of new science curricula based on the qualitative inspection of individual study results of student performance is bound to be frustrated by the sheer numbers of studies involved and their inherent complexity.

Summary statements regarding the impact of new science curricula on student performance based on a quantitative integration of the research literature were presented. The quantitative integration technique used is known as "meta-analysis" (Glass, 1976). Meta-analysis utilizes the variance reported in the individual research studies as a common metric in the analysis of results from multiple studies on a common question. In essence, meta-analysis is the "statistical analysis of the findings of many individual analyses" (Glass, 1978, p. 352).

The results of the meta-analysis of studies on the impact of new science curricula on student performance reveal several interesting trends. Across all new science curricula analyzed, students exposed to new programs performed better than their traditional course counterparts in achievement, analytic skills, process skills, and related skills, and developed a more positive attitude toward science. On a composite measure, the average student in new science curricula exceeded the performance of the students in traditional science courses by 13 percentile points.

Further breakdowns of the student performance data reveal other interesting effects of new science curricula. For example, new science curricula in biology produced the most positive performance scores among the science disciplines, while chemistry and earth science curricula appeared to have had the least positive impact. Also, studies involving new science curricula judged to have a low emphasis on laboratory activity showed students outperforming their traditional

course counterparts by larger margins overall than those new science curricula judged to have a high laboratory emphasis. But in both cases, students in the new science programs outperformed traditional course students, suggesting an overall positive impact of laboratory-based instruction.

Studies involving new science curricula judged to have a high emphasis on process skill development showed students outperforming traditional course students by larger margins on analytic skill measure than those involving curricula judged to have a low process skill emphasis.

In terms of overall performance, science curricula produced equally positive results when broken down by grade level (K-6, 7-9, 10-12, post-secondary). However, student performance in new science curricula was significantly enhanced where mixed samples of male and female students were studied compared to either predominately male or female samples.

Finally, the quantitative synthesis suggests that teacher inservice training was not effective in producing significant gains in student performance compared to teachers who had received no formal inservice work. Alternative explanations for this and other findings were thoroughly discussed in the presentation.

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ISTS Analysis of Daily Conference Themes

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Elementary School Science

A concern was voiced regarding the curriculum materials (i.e., textbooks, published kits, etc.). Where are they going? Will there be more hands-on materials like SAPA, ESS, etc., or less? Many teachers feel uncomfortable in science because they do not have strong backgrounds. The inquiry types of materials also require a great deal more preparation time and th s must compete with the other subject areas for the teachers' preparation time.

How can education be made more exciting? Can it compete with the entertainment of TV and computers and the like? In the past the new and unique things and ideas of society were often found in the schools. Today due to mass communications and microcomputer technology, the schools have lost that edge to the TV, home, and other elements of society. Students may need to observe and study ants attacking a drop of honey, but will that compete with futuristic space travel with Buck Rogers and Twiggy, the "humanistic computer?"

Physical Science

The major concern expressed centered around the problem of Chemistry/Physics education versus general physical science education. This is especially critical at the senior high school level. The actual state indicated we are functioning primarily in the college prep. Chemistry/Physics area. Larger schools can have an option by providing alternative courses for non-college bound students. However, the problems of small schools with only one science teacher and a small number of students does not allow for multiple courses. All science students will have to be

taught in the same class.

Another major problem is a definite lack of curriculum materials in the physical sciences that focus upon science issues other than the basic chemistry and physics principles. Some programs such as Interdisciplinary Approaches to Chemistry are including more applications and descriptive science, but is certainly not issue-centered. Many of the ISIS physical science modules are issue-oriented but they deal with most topics at a junior high level and lack the "college-prep" rigor sought by most physics and chemistry teachers. Thus they do not get included in most Chemistry and Physics classes.

Inquiry

Most of the inquiry focus seemed to be toward the elementary/middle school level. The same problems were raised as in the elementary discussions. Where does the teacher get the extra time required to prepare to teach inquiry science? Is there a source of inquiry ideas such as the fizzing pop Dr. Aikenhead used? Most teachers cannot discover these on their own. If there was a publication with suggestions and ideas for inquiry activities, it would at least help those who are interested in teaching in this manner.

Biological Education

Dr. Bybee's focus was more on science education in general rather than biological education specifically. The general topic was presented for discussion as suggested by Dr. Bybee:

"Science education programs should include objectives that will:

1. fulfill basic human needs and facilitate personal development;
2. maintain and improve the physical and human environment;
3. conserve and efficiently use natural resources;

4. develop greater community at the local, regional, national, and global level."

These goals were ones that are difficult to quarrel with. The difficulty arises in implementation. Many of the recurring problems presented during the week again were mentioned. Will published materials reflect these ideas? How will preservice programs instill these goals into beginning teachers? What can be done about inservice to teachers in the field? What are the issues and topics that should be used to a central focus for the curriculum? How will they continue to change? How will teachers know they have changed?

Science/Technology/Society

Dr. Piel shared with the group some of the materials being prepared in monograph form. He felt a technology course, such as The Man Made World could not successfully replace or become an addition to the entrenched disciplines. These monographs deal with a single technological concept and thus can be used as supportive material in an existing course. Most participants showed a great deal of interest since the question of curriculum resource materials dealing with social issues had been raised several times during the week.